Ethnobotany, phytochemistry, and pharmacology of *Fritillaria cirrhosa* D. Don: A bibliometric analysis of an alpine medicinal herb

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Review

Abstract

Background: Fritillaria cirrhosa D. Don is a high-value alpine medicinal herb endemic to the Himalayan region, valued in traditional Asian medicine for its antioxidant, anti-inflammatory, and respiratory benefits. Its bulbs command high market prices, leading to unsustainable harvesting, ecological threats, and endangered status (IUCN Vulnerable). Despite its ethnobotanical, phytochemical, and pharmacological significance, research trends and gaps remain underexplored, necessitating a bibliometric analysis to map scientific output, collaborations, and future directions for conservation and sustainable use.

Methods: This bibliometric study analyzed publications on *F. cirrhosa* from 1939 to June 2025, retrieved from the SCOPUS database using search strings targeting "*Fritillaria cirrhosa*" and synonyms like "*Fritillaria roylei*." Data were processed with VOSviewer for network visualization (co-authorship, co-occurrence) and R Studio (Bibliometrix) for trends, citations, and thematic mapping.

Results: A total of 128 documents were analyzed, revealing China's dominance (89 documents, 1538 citations), followed by India (24 documents, 250 citations) and Hong Kong (17 documents, 368 citations). Top institutions included Sichuan University (53 articles) and Chengdu University (51 articles), with key authors like Wang S (h-index 7, 266 citations), Li, P (h-index 6, 270 citations). Citation analysis showed recent publications gaining rapid impact, while keyword clusters emphasized traditional medicine, alkaloids, and pharmacology. However, from 2020 onwards, the publication and citation record or research output of the *Fritillaria cirrhosa* drastically increases, which signifies that the species globally is gaining attention among researchers.

Conclusions: This first bibliometric analysis highlights research imbalances, with negligible contributions from other Asian countries like India, Nepal, and Pakistan. Despite the rich species' distribution in the countries, the publication and citation trends were still restricted. This would largely impact the species' global attention and scientific evidence at the international level.

Keywords: Fritillaria cirrhosa, Medicinal properties, R Studio, Forest product, NTFP, Ethnobotany.

Background

The *Fritillaria cirrhosa* D. Don (FC) with genus *Fritillaria* (Liliaceae family) consists of more than 130 species (Bi *et al.* 2018), endemic to the Himalayan region, and is well-known for its high medicinal properties (Khanam *et al.* 2023). The species is harvested and traded under the name *Jungali lehsun*, probably due to its similarity (mainly in the bulb) with several Allium species (Kumar *et al.* 2021; Mathela *et al.* 2021), although it belongs to the family Liliaceae. Also commonly called *Kakoli* in Asia and *Nonybhutkesh* in Uttarakhand, the species is widely harvested for its immense medicinal applications. It acts as an antioxidant, rejuvenator, aphrodisiac, and tonic (Dhyani *et al.* 2022). The species is also one of the components of the "Ashtavarga" (group of eight plants), which has been reported as a potential herb for rejuvenating health rapidly and acting as a good antioxidant (Marde *et al.* 2019). It is among the 36 globally significant medicinal plants found in the Western Himalayas with high market and trade demand in Asian as well as European countries (Bisht *et al.* 2016; Cunningham *et al.* 2018), widely distributed along the temperate regions of Asian countries with several applications in traditional medicine systems, especially in Traditional Chinese Medicines (TCM) systems, Ayurveda, and Himalayan ethnomedicines (He *et al.* 2006; Singh *et al.* 2012). However, the reported trend of unsustainable harvesting patterns, climate change, grazing pressure, unawareness among locals, and many other abiotic or biotic stresses on the species place it as 'Vulnerable' as per the IUCN (International Union for Conservation of Nature) Red List and Endangered as per CAMP, (Conservation assessment and management prioritization (Ved *et al.* 2003).

Consequently, immediate sustainable conservation strategies are required to conserve the species before it reaches the verge of extinction. Implementing conservation efforts will help achieve SDG 15 (Sustainable Development Goal): Life on Land, which further emphasizes preventing biodiversity loss and the extinction of species. Despite the emerging interest in the medicinal properties of the species over the past few years, there is a dearth of bibliometric reports that focus especially on the importance of this rare medicinal herb. Although FC is widely studied, many areas still have untapped potential. Hence, there is an immediate need to comprehensively and systematically understand past and present research trends. The key contributions of this study are structured around the following interconnected research questions: -

Q1: Why was *Fritillaria cirrhosa*, an alpine medicinal herb, specifically chosen as the focal species for this investigation?
Q2: Which institutions, countries, and authors have made significant contributions to the research on *Fritillaria cirrhosa*?
Q3: How have keyword patterns, research themes, and related studies evolved over the past decades in the field of *Fritillaria cirrhosa* research?

These research gaps and intended future strategies are beneficial in fully harnessing the medicinal benefits of the *Fritillaria cirrhosa* and promoting livelihoods to the local community through sustainable harvesting practices. This bibliometric study is a quantitative analysis that provides a visual mapping of the data through statistical evidence, making it easier for researchers to identify influential contributors, collaborators, and research records of the species.

Materials and Methods

Bibliometrics is a quantitative analysis of data to determine the research trend and its publication in a respective field (Omoregbe *et al.* 2020). This quantitative analysis uses data to investigate collaboration among authors, their scientific outputs and innovations, researchers' works, institutional networks and contributions, and countries' research output (Obileke *et al.* 2022). Although it is the first-ever bibliometric analysis of an FC. In this investigation, comprehensive data on participation and networks among global authors, affiliations, and journals, extracted from the Scopus database, were exhibited. The SCOPUS database was used for the data extraction of FC to thoroughly and systematically gather the relevant data published over the years, and R Studio for generating graphs (Fig. 1 & 2) (Santos *et al.* 2025). The quantitative analysis of the research output of the *Fritillaria cirrhosa* was limited to the period from 1939 to June 2025, extracted in June 2025, ensuring the most relevant and recent publications were selected through the SCOPUS Database. This ensures in maintains homogeneity is maintained and improves accessibility for a larger academic audience (George et al.,2021). The employed search strategy with specific related keywords to the medicinal herbs under the investigation, especially targeting: "*Fritillaria, "Fritillaria cirrhosa", "Fritillaria roylei".*

The overall search string used was*: (*TITLE-ABS-KEY ("Fritillaria") AND TITLE-ABS-KEY ("*Fritillaria cirrhosa*") OR TITLE-ABS-KEY ("*Fritillaria roylei*") AND ((LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (LANGUAGE, "English")). The necessity of uniformity and accuracy is required for the analysis of past works and predictions of future trends. Enclosure criteria were cautiously defined to safeguard the specificity and relevance of the studies. The included data explicitly identified the plant by its scientific name, which will minimize the risk of misidentification of irrelevant data.

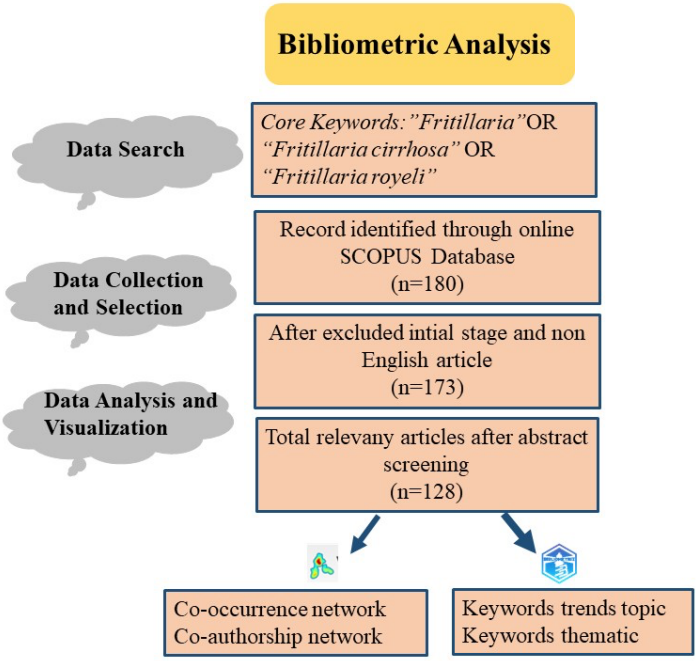


Figure 1. Diagrammatic representation of Bibliometric screening and Data mining.

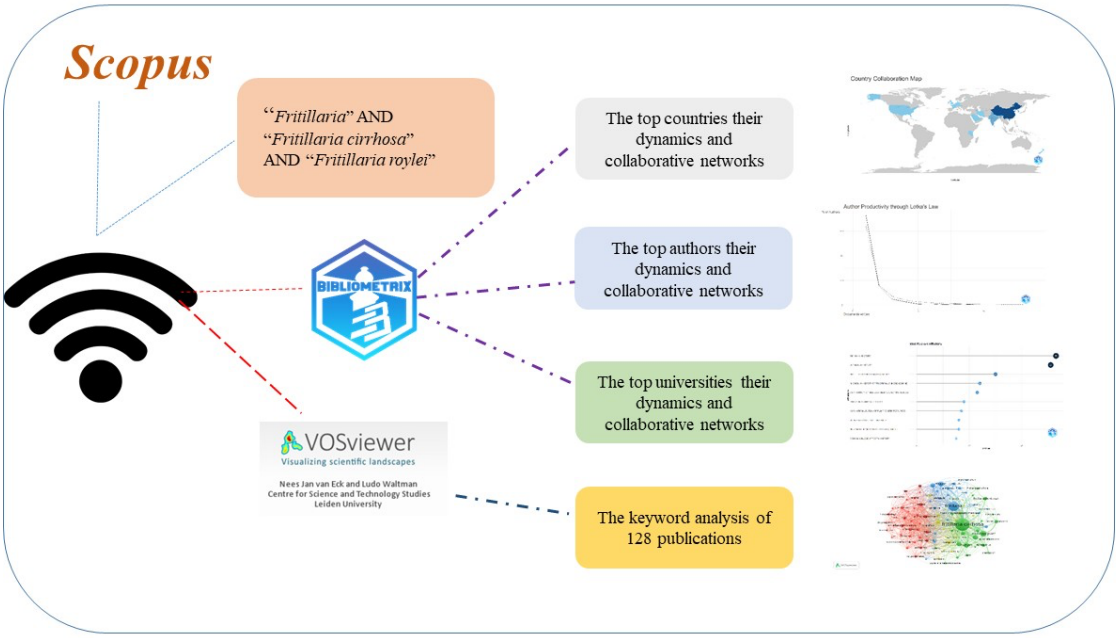


Figure 2. The methodology followed for the study was the SCOPUS database, using relevant documents, such as journal articles and conference papers published on *Fritillaria cirrhosa* research, carried out using the VOS viewer software version 1.6.15(2020), and R Studio (Bibliometrix: http://127.0.0.1:6243/.

Result and Discussion

Publication and citation records

The overall analysis of the publication from 1939 to 2025 encompasses a total of 128 manuscripts. The Mean TC per Art (mean number of total citations per article) and Mean TC per Year (mean number of citations per year) exhibited notable variations. The data is presented in (Table 1). The top 10 cited articles with their citation rates reveal diverse trends in citation dynamics and influence over time. The maximum total citation was recorded by *Guo Y* (2020), *Arabian Journal of Chemistry,* 72 citations and an average of 12.00 citations per year: the highest mean TC per year among the listed. This further indicates a robust and reliable citation performance regardless of being a recent publication. Similarly, *Park I (2017)*

and *Cunningham AB (2018)* acquired 69 and 70 citations, respectively, with mean TC year values of 7.67 and 8.75, validating annual visibility and sustained academic interest. The publication and citation record analyisis through bibliometric analysis reveals the dynamic research development from 2020 onwards with an increase in publications and citation rates. This upwards escalating records highlight the global research interest of the researcher on the species. This would further highlights the key contributions of only Chinese authors in the relevant species *Fritillaria* with significant citation records.

Table 1. Represents the top 10 publications, their citation rates.

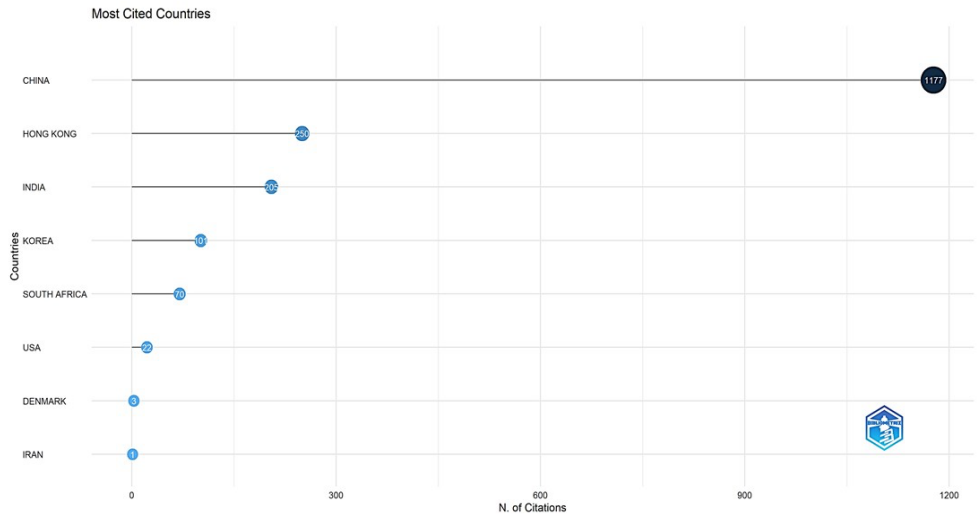
S. No.	Paper	Total citation	TC per year	Normalized TC
1	GUO Y, 2020, ARAB J CHEM	72	12.00	2.99
2	CUNNINGHAM AB, 2018, J ETHNOPHARMACOL	70	8.75	1.91
3	PARK I, 2017, MOLECULES	69	7.67	2.71
4	CAI ZH, 1999, PLANTA MED	62	2.30	1.04
5	LI S-L, 1999, J CHROMATOGR A	57	2.11	0.96
6	XIN G-Z, 2014, ANAL CHIM ACTA	52	4.33	1.42
7	WANG D, 2016, J ETHNOPHARMACOL	52	5.20	1.46
8	WU X, 2018, J ETHNOPHARMACOL	51	6.38	1.39
9	WU K, 2015, PLANTA MED	50	4.55	1.18
10	ZHAO Q, 2018, PLANT BIOSYST	48	6.00	1.31

Earlier citations, such as *Li S-L (1999)* and *Cai ZH (1999)*, while having fewer citations per year (2.11 and 2.30, respectively), have acquired substantial total citations over time (57 and 62). It indicates the enduring relevance of these works for instance, their normalized citation values (0.96 and 1.04) are less compared to more recent high-impact publications, Normalized citation(NC) values aid in accounting for the publication period, and this shows that some recent documents, such as *Wang D (2016)* (1.46), *Park I (2017)* (2.71), and *Guo Y (2020)* (2.99), are performing persuasively even when attuned for time. Manuscripts published between 2014 and 2018 govern the list, emphasizing a productive period with continued scholarly interest. For instance, *Zhao Q (2018), Wu X (2018), Wang D (2016), and Xin G-Z (2014)* all unveil balanced metrics in total citations and mean TC per year, with NC varying from 1.46 to 1.18 (Table 1). This demonstrates that mid-2010s publications have been exclusively significant and continue to persuade current research trends.

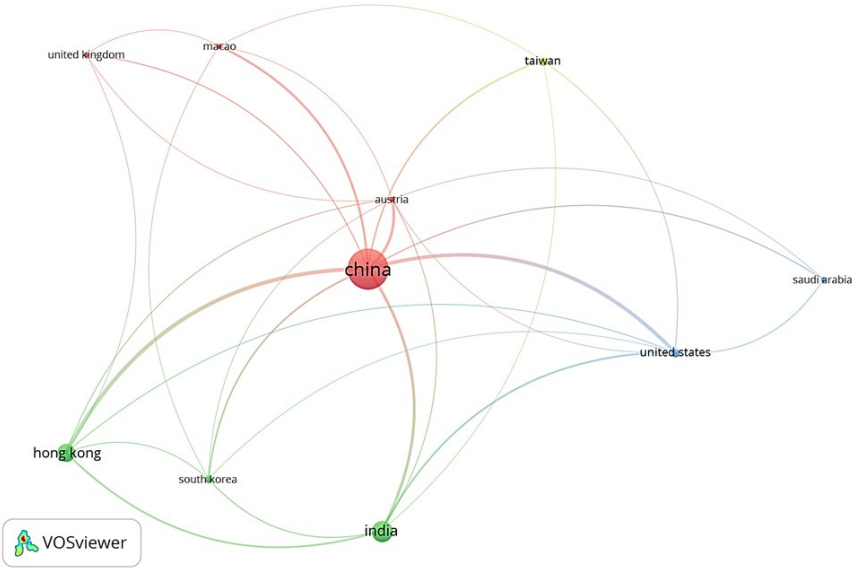
Additionally, Table 2 represents the ten top-most cited countries with their total citation and average article citations. China became one of the top-cited countries with a total citation of 1177; however, the average citation per article was moderate (14.70). South Africa has the maximum average article citation (70.00), followed by Hong Kong (41.70) and Korea (50.50), indicating the strong influence of individual assistance from these countries. Further, India contributed with 205 citations, with a lower average per article (10.80), highlighting scope for developments in citation impact and research visibility (Fig. 3A & B). These finding suggests the pattern underlines both the quality and quantity dimensions of global contributions and collaborations.

Table 2. Top-most cited countries/regions and their average article per citation

Country/regions	TC	Average Article Citation
China	1177	14.70
Hong Kong	250	41.70
India	205	10.80
Korea	101	50.50
South Africa	70	70.00
USA	22	22.00
Denmark	3	3.00
Iran	1	1.00



(A)



(B)

Figure 3 (A) & (B). Top countries, their dynamics, and the collaboration network

The overall research pattern suggests a shift, where more recent publications are achieving high citation rates within a short time interval, likely due to digital platforms and broader networks. The normalized citations metric highlights the emerging trend, where recent documents are rapidly gaining recognition. However, earlier foundational papers still sustain relevance through long-term aggregate citations, accentuating their persistent value in the literature. In conclusion, the interpretation highlights that recent papers receive citations and show high short-term impact, while older publications continue to contribute foundational knowledge to the field. This reinforces the importance of accounting for multiple citation metrics—normalized citations, annual citation rates, and total citations —to precisely deduce a publication's impact over time.

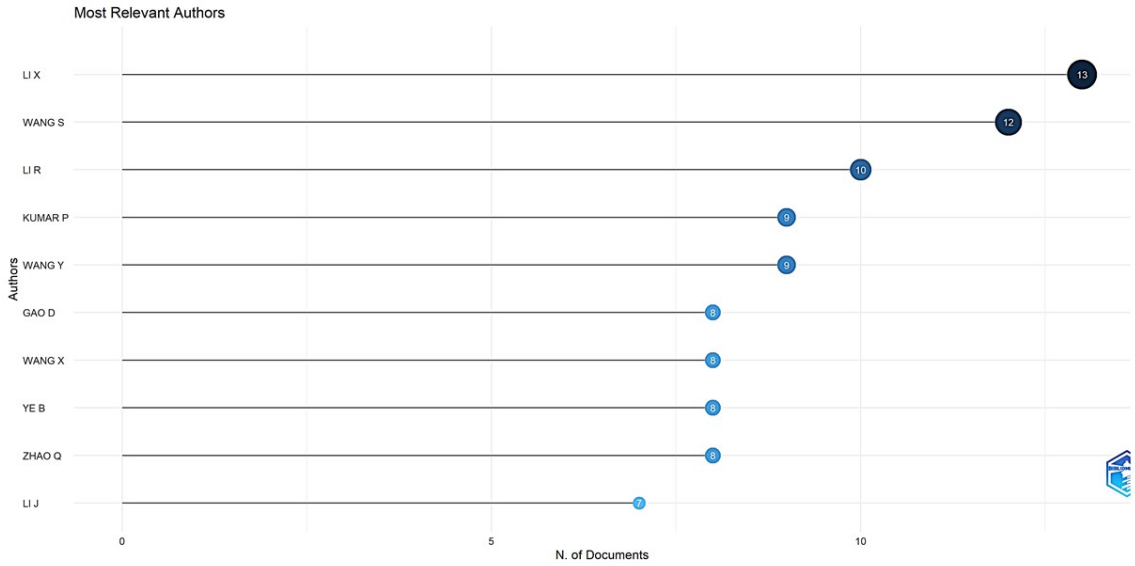
Top authors, Universities, and countries

Exhibiting the top countries, institutions, and authors in bibliometric analysis is significant for mapping the scholarly landscape of a research field. Foremost, the authorship network (Table 3). Wang, S has a commendable h-index (Productivity and citation impact) (Santos *et al.* 2025) of 7 and TC (total citations) 266 among the 12 publications, commencing scholarly output in 2006. Li, P. exceeds all citations count (TC=270), regardless of having only 7 publications and a comparatively low g-index (Impact of top-cited papers) (Santos *et al.* 2025) of 7. This indicates the work is highly impactful in his early career. Li, R, with an h-index of 6 and a highest m-index (Research consistency over time) (Santos *et al.* 2025) (0.750), is a significant

contributor to the hasty academic influence since 2018, and a prominent key contributor. Similarly, Kumar, P, holds the maximum m-index (0.833) amongst the best authors with intense productivity since 2020 (Fig. 4A & B). These metrics not only suggest the volume of research but also the impact and intensity of research that eventually guide the beginner scholar towards potential collaborations and works.

Table 3. Represents the Top 10 most cited authors with their total citations, h, g, and m index.

Authors	h_index	g_index	m_index	TC	NP	PY_start
Wang S	7	12	0.350	266	12	2006
Li P	6	7	0.222	270	7	1999
Li R	6	10	0.750	136	10	2018
Li X	6	9	0.353	96	13	2009
Ye B	6	8	0.545	144	8	2015
Kumar P	5	9	0.833	140	9	2020
Li J	5	7	0.625	88	7	2018
Wang X	5	8	0.385	102	8	2013
Zhao Q	5	8	0.625	130	8	2018
Chen S	4	4	0.235	91	4	2009



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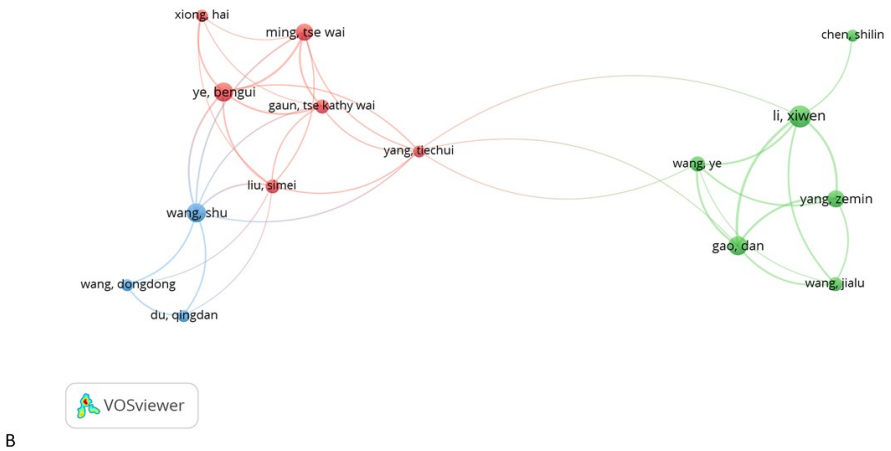


B

Figure 4(A) & (B). The top authors and their dynamics and collaborations

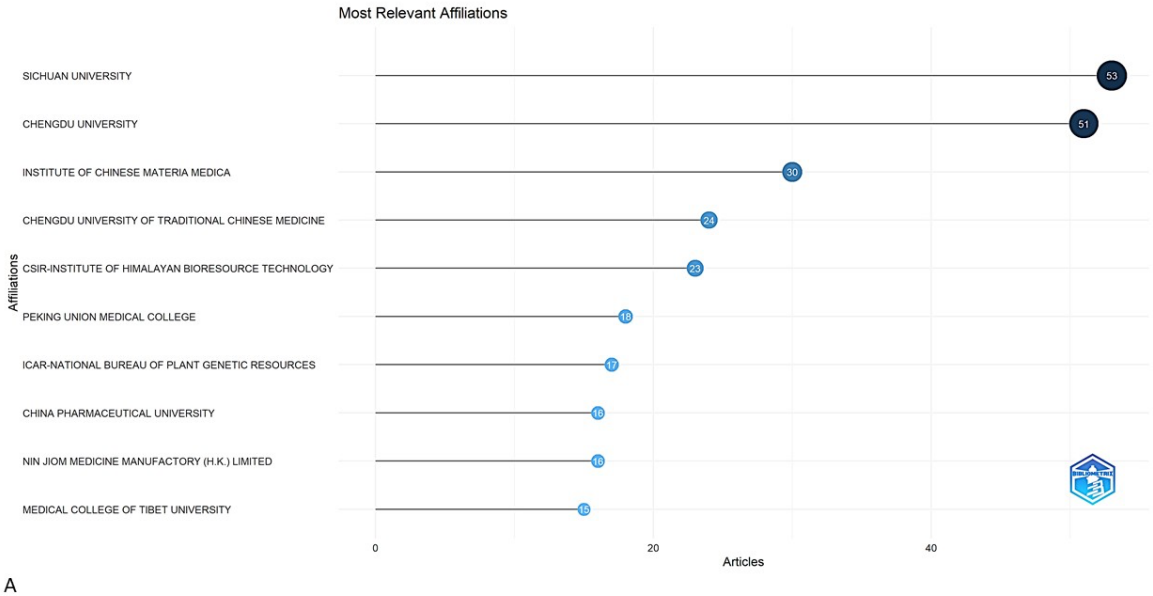
With regard to institutional contributions (Table 4), Chengdu University and Sichuan University indicate 51 and 53 documents, authenticating themselves as the hotspot of research in this domain. Due to their geographic proximity to the *Fritillaria cirrhosa* natural habitat in Sichuan province of China, and frequent national collaboration in the phytochemical as well as molecular research. This consolidated their leading role in the research with respect to *Fritillaria cirrhosa.*

Table 4. Shows the top 10 universities/institutions with their articles

Affiliations	Articles
Sichuan University	53
Chengdu University	51
Institute of Chinese Materia Medica	30
Chengdu University of Traditional Chinese Medicine	24
CSIR-Institute of Himalayan Bioresource Technology	23
Peking Union Medical College	18
ICAR-National Bureau of Plant Genetic Resources	17
China Pharmaceutical University	16
Nin-Jiom Medicine Manufactory (H.K) Limited	16
Medical College of Tibet University	15

Although some institutions, such as Chengdu University of Traditional Chinese Medicine (24 publications), Institute of Chinese Materia Medica (30 Publications), and China Pharmaceutical University (16 publications), deliberately sustained China's capitalization in traditional medicine and bioresources innovation (Fig. 5A & B). However, Indian institutions such as CSIR-IHBT, ICAR-NBPGR, and Medical College of Tibet University stand out with 23, 17, and 15 articles that play a pivotal role in ethnobotanical research, emphasizing the role of national and region-specific research in the scientific proceedings.

China governs the bibliometric output with a maximum of 89 documents with 1538 citations at the country level, interpreting their leadership in terms of impact and quantity (Table 5). India contributes 24 documents with 250 citations, demonstrating the emerging regional engagement and strength. Further, Hong Kong published 17 documents with 368 citations, which signifies a maximum citation per document ratio that reflects impact and quality. Other prominent contributors include South Korea (3 articles with 103 citations), the United States (4 articles with 169 citations), followed by Austria (2articles with 95 citations), suggesting academic anticipation between transcontinental countries. This geographical uniformity underlines the universal nature of the research outputs and the benefits of the international collaborations in the expansion of scientific frontiers.



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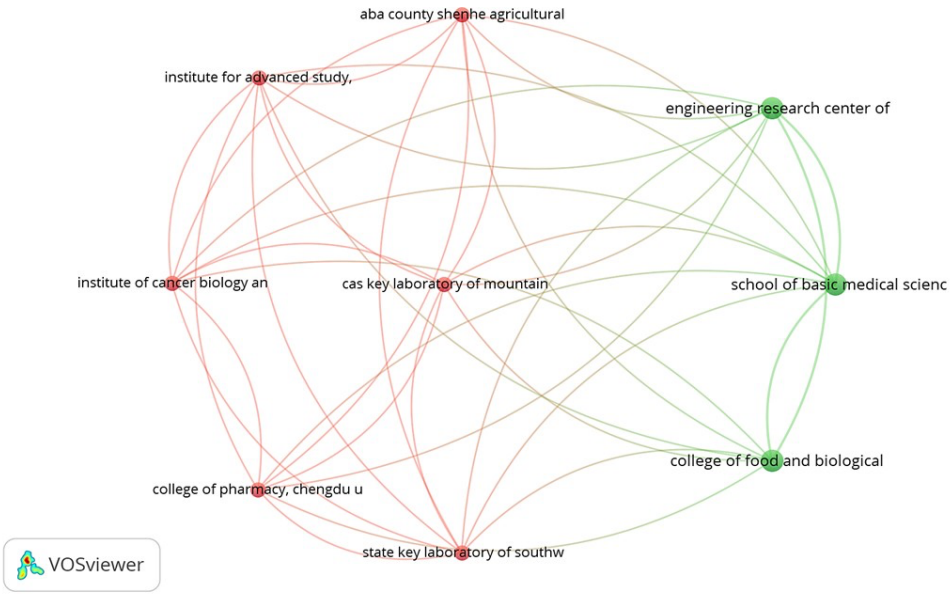

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Figure 5 (A)&(B). Top Universities: their dynamics and collaboration networks

Table 5. Top ten countries with high citations and documents

S. No	Country/Region	Documents	Citations
1	China	89	1538
2	Hong Kong	17	368
3	United state	4	169
4	India	24	250
5	Austria	2	95
6	Macao	3	50
7	South Korea	3	103
8	Taiwan	4	68
9	Saudi Arabia	2	26
10	United Kingdom	2	30

The co-authorship analysis interprets the deeper insights into the collaborative frameworks of the research dynamics. Authors such as Wang X (m-index 0.385) and Ye B (m-index 0.545) show the emerging co-authorship and intellectual exchange since 2013 and 2015, respectively. Li, J, and Zhao, Q. (m-index 0.625) show the highest m-index values amongst the recent researchers, indicating their impactful collaborations and integrations in their early research career. These trending patterns highlight the presence of anticipated research networks that hasten the information dissemination and multidisciplinary synthesis. The Bibliometric analysis of the *Fritillaria cirrhosa* potentially concluded the dominance of the Chinese authors, institutions, and their national collaboration in terms of research output as compared to other native ranges in the Asian sub-continent. This might further challenge the other developing countries to contribute and collaborate more for finding the invaluable research advancement regarding *Fritillaria cirrhosa* with respect to its medicinal, conservation, phytochemistry, and molecular applications.

In conclusion, collaboration at the national and institutional level demonstrates the hotspot of innovation and interaction. In this regard, China's predominance across the national metrics, institutional, and author points to a resilient internal collaboration network. Meanwhile, countries like South Korea and Austria show high citation impact despite having lower publication records, pointing to effective international research networks. These Findings provide insightful evidence of shaping research grants, fostering global academic networks, and referring to geographical discrepancies in scientific productivity.

Co-words analysis of papers and thematic mapping

Co-word analysis is a significant bibliometric process used to reveal the association with research concepts via keyword co-occurrence. In this analysis, we process 128 publications with 2456 extracted keywords, of which 46 meet the least co-occurrence threshold (Fig.6). The data have been grouped into three major clusters with colours Red, Green, and Blue demonstrating its centrality in interdisciplinary research. The first cluster (red colour), focused on traditional medicine and ethnobotany, highlighting keywords such as *Fritillaria cirrhosa* (n=77, n= indicating number of occurrence of keywords), *Fritillaria* (n= 74), Chinese medicine(n=16), medicinal plant(n=26), and plant extract(n=27). *Fritillaria cirrhosa* emerged as the most frequent keyword with a maximum total link strength (297), representing its central role in the literature. Further, Cluster 2 (Green colour), highlighted botanical and phytochemical studies with terms like alkaloids(n=23), alkaloid(n=26), plant root(n=13), plant bulb (n=10), and anti-inflammatory(n=10). The cluster accentuated alkaloid compounds and therapeutic potential, with bioactive compounds showing the highest citation performance (normalized:1.41; avg citation:19.7). Additionally, cluster 3 (Blue colour), focused on analytical and pharmacology, including pathology (n=12), peiminine (n=12), and metabolism(n=23). Pathology and peiminine had the maximum normalized citation scores (1.44 and 1.50), indicating recent impactful research. Significantly, liquid chromatography-mass spectrometry(n=10) had the maximum recent average. publication year (2023), suggesting growing interest in advanced analytical methods. Overall, the temporal analysis revealed a shift from traditional studies to trending recent pharmacological and alkaloid compounds. This multidisciplinary research integrates the traditional knowledge, therapeutic evaluation, and chemical profiling of FC is one of the potential focal species in the study.

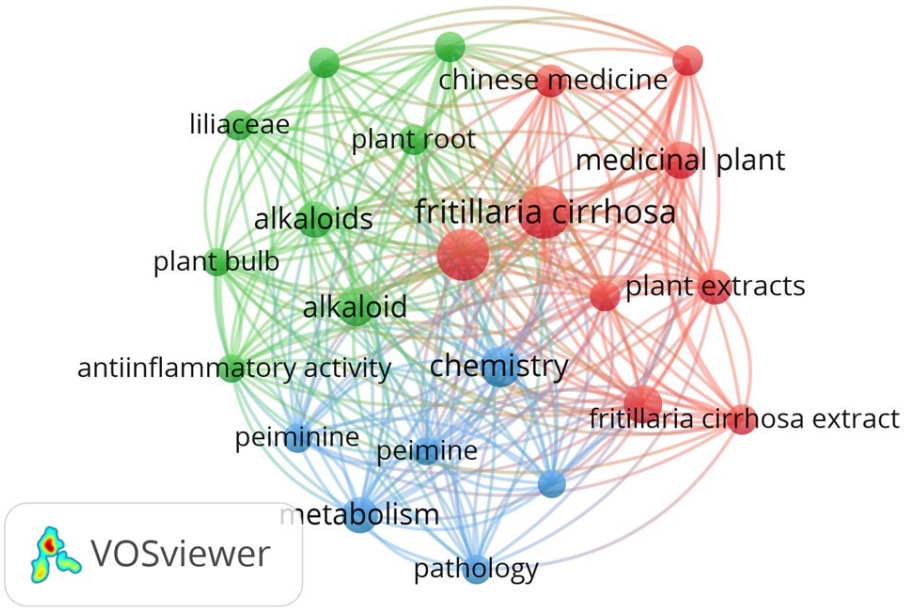

Figure 6. All keywords analysis

Thematic Mapping

The thematic mapping is typically divided into four quadrants: Motor themes, Niche theme, Basic and Tranuniversal themes, and emerging or declining themes, which interpret centrality and density of the data. Although analysis of the 128 documents is highly related to *Fritillaria cirrhosa* and closely related keywords states the motor themes (high centrality, high density) *Fritillaria* and *Fritillaria cirrhosa*, indicating a central and well-developed research domain. While basic themes with low centrality, high density, include *liliacea, medicinal plants*, and *genetics*, are connected among diverse studies, but yet require profound advancements. Further, niche themes (Low centrality, high density), like *China and phylogeny*, were identified as highly advanced but scarcely focused. The emerging or declining themes (low centrality, low density), keywords like *biodiversity, climate change*, and *India*, these themes are either early stages of integration or in decline in current research relevance (Fig. 7). This thematic map potentially highlights the dynamic research landscape, its nature, and balances central themes with growing research directions, and categorizes gaps for future exploration.

Phyto-chemistry, medicinal importance, trade, and market

The world has been understanding the side effects triggered by modern synthetic medicines. Which has been enormously tilted towards homeopathy and naturopathy. Therefore, FC is one of the potential herbal medicinal plants, which is a highly beneficial and potent medication in the traditional medical system (Chandra *et al.* 2021). The significant pharmacological

steroidal alkaloids found in the bulb of *F. cirrhosa* include verticillin, peimine, verticin, and peiminine, etc. show antioxidant, antissusive, anti-asthmatic, and anti-inflammatory properties (Chauhan *et al.* 2011). Further, Bhat et al. (2022) reported the occurrence of 88 phytochemicals in the extract of *F. cirrhosa* bulb, and some of the potential bioactive components are sinpeinine A, imperialine, and peonidin (Fig. 8). All these bioactive compounds show diverse metabolic actions, encompassing anti-asthma, relief from mucus, and antitussive impacts (Wang *et al.* 2021). These metabolites further show anti-cancer properties against uterine and ovarian cancer (Kavandi *et al.* 2015), prostate cancer (Kardan *et al.* 2019), and lung cancer. Bhat et al. (2022) reported that the extract of FC shows anticancer activity in an in vitro experiment for the treatment of breast cancer. The species has gained a plethora of consideration due to its immense aforementioned bioactive compounds and medicinal importance (Dhyani *et al.* 2022). This ultimately strengthens the economic and commercial importance of this high-value medicinal plant in traditional Chinese medicine and the Indian medical system (Jiang *et al.* 2022).

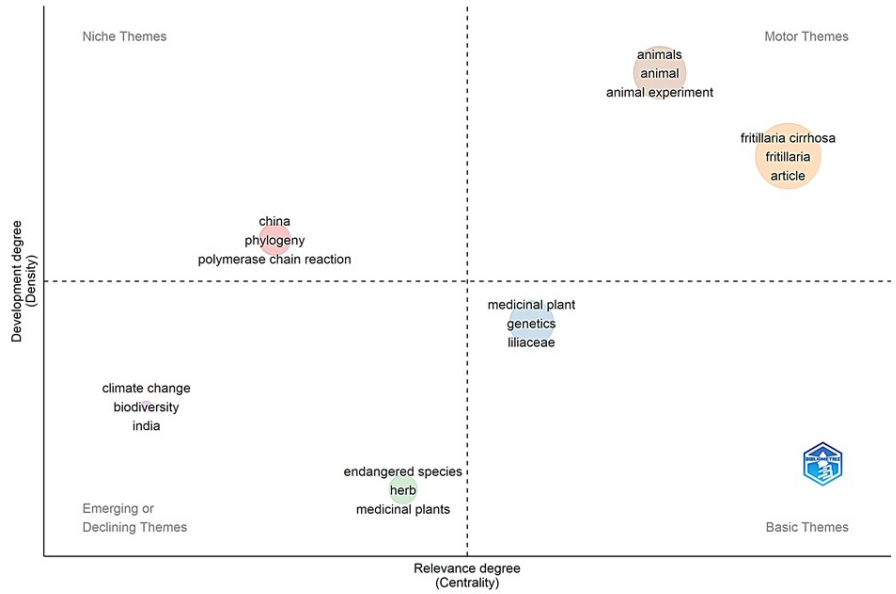

Figure 7. Thematic Map

Fritillaria cirrhosa is an active ingredient in the preparation of traditional herbal medicine in Canada, Australia, the Republic of Korea, Hong Kong SAR, Taiwan, Singapore, Malaysia, Europe etc, for the respiratory and other metabolic disorders (Cunningham *et al.* 2018). It is in active cross-border trade, and demand for bulbs is exclusively high in China, India, and Nepal. This further pressurizes the wild population of the species, where they are naturally found, to fulfill the increasing demand of the market. It eventually stands out as the most extensively harvested medicinal bulb species of the alpine region of China, Nepal, and India. Due to the surpassing demand over supply, there is a dramatic rise in the average price of *F. cirrhosa* bulbs. For instance, China is the largest trading center for FC bulbs, and the demand for wild-harvested FC has a drastic worth of 400 million *US$* per annum (Cunningham *et al.* 2018; Kumar *et al.* 2021; Mathela *et al.* 2021). Khanam et al. (2023) reported that the price of a dry bulb of FC is 15000/kg in the local Indian market. Further, Kumar et al. (2021) and Mathela et al. (2021) documented that the average annual exported trade of FC in the Pangi landscape, Himachal Pradesh, between 2017- 2021, was 291.16 quintals.

Given the medicinal significance of this plant and the myriad challenges it faces, there is a compelling need to accord priority to its conservation (Mathela *et al.* 2021). However, in India, the collection of bulbs from the wild is legally allowed for the natives of Himachal Pradesh (Bisht *et al.* 2016), and harvesting is banned in the state of Uttarakhand (Khanam *et al.* 2023). Therefore, considering the threats and its conservation in view, it is crucial to conserve this high-value medicinal herb without compromising the wild population in its natural range.

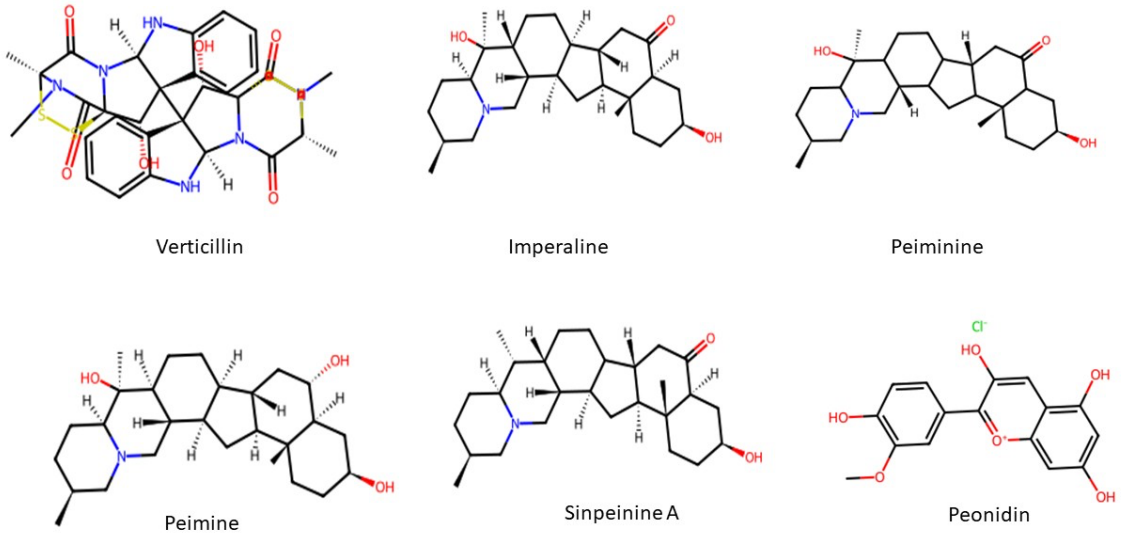

Figure 8. Structure of most potential phytochemicals found in *Fritillaria cirrhosa*

Ethnobotanical Research and Application of *Fritillaria cirrhosa*

The bulbs of *Fritillaria* "Bulbous Fritillariae" are dried and powdered, orally administered in an amalgamation of other herbs, for respiratory disorders (Manandhar, 2002). The ethnobotanical research of *Fritillaria roylei* Hook. syn. *Fritillaria cirrhosa* D. Don is one of the significant livelihood resources and a culturally valued medicinal plant of the Himalayan regions of the Asian countries (Joshi & Edington, 1990). For instance, in Nepal, the plant is used for colds and sore throats as well as in religious rituals (Manandhar, 2002). Similarly, in China, known as "Chuan Bei Mu" in TCM, the species has been a medication for several respiratory diseases across the traditions (Cunningham *et al.* 2018). Further, ethnobotanical surveys in Himachal Pradesh and Uttarakhand ensure the continued dependence of local communities on this species for livelihood and medicinal uses (Kala 2004; Singh & Rawat 2011). The documentation and preservation of the ethnobotanical knowledge further promote sustainable practices. This will safeguard the medicinal value of the *Fritillaria cirrhosa* as well conservation of the wild habitat of the species for the subsequent generation.

Table 6. Traditional applications of *Fritillaria cirrhosa* in different countries.

Part Used	Ethnobotanical Application	Preparation method	Country/region	References
Bulb	Asthma, Bronchitis, Cough	Powder of dried bulb consumed with honey or warm water	India, Nepal	Nautiyal *et al.* 2002; Kala *et al.* 2004
	Demulcent, Expectorant	Decoction of bulbs	Uttarakhand (India)	Ved *et al.* 2003; Samant and Dhar 1997
	Respiratory disorders, Tuberculosis treatment	Boiled bulbs mixed with milk	Nepal, Himachal Pradesh (India)	Bhattarai *et al.* 2010; Gaur 1999
	Anti- inflammatory	Paste of dried bulb externally applied or orally administered	China, Tiber	Zhao *et al.* 2003
	Lung infection, chronic cough	Orally administered pills and powder	Indian Himalaya, China, Nepal	Olsen & Larsen 2003; Kala 2005
	Cold, Pneumonia	Powder of dried bulb	Kashmir, Himachal Pradesh	Dhar *et al.* 2000
	Throat swelling, Remedy for goiter	Powder of the bulb taken with warm water	Kumaon Himalayan region, Nepal	Joshi & Edington 1990; Nautiyal et al. 2001

	Purifies blood and reduces toxins	Decoction	China (Sichuan Yunnan)	Chinese Pharmacopeia 2011; He *et al.* 2006
	Snake bite Antidote	Crushed bulb externally applied	Tibetan plateau, Ladakh	Kletter & Kriechbaum 2001
	Chinese raw drug and Ayurvedic high value trade	Collected, dried and sold by locals to cross borders	Indian Himalaya, China, Nepal	Olsen & Larsen 2003; Kala 2005
	Aphrodisiac	Bulb powder taken with milk	Nepal, India (Uttarakhand)	Singh *et al.* 2012
	Ritual and religious practices (Sacred Offerings)	Dried plant offered	Nepal Himalaya	Manandhar 2002

Ecology and Conservation Strategy

Fritillaria cirrhosa usually thrives in light, shady to mild, loamy, well-drained, acidic pH soil that is rich in organic substrates. Due to the inhabitant herbs of alpine meadows, seeds become dormant throughout the winter and bloom in the vernal season. The preferred vegetation type of FC is temperate forest, including Oaks, Pines, Rhododendrons, and Firs, and open Grasslands near streams. The ideal habitat also entails alpine meadows with temperatures of 4-5°C, moist soil with dappled sunlight, and altitudes between 2600-4600 amsl. It is conventionally propagated by seeds and somatically via daughter bulbs, due to its prolonged cold stratification at 4-5°C for the cycle of 80-90 days for foliage growth and 270-80 days for subterranean development, leading to hindered propagation (Khanam *et al.* 2023). Consequently, *Fritillaria cirrhosa* cultivation has been unable to meet the increasing market demand for bulbs, although other species of FC are effectively cultivated on a wider scale. For instance, *Fritillaria thunbergi, Fritillaria palladiflora, Fritillaria meleagris,* and *Fritillaria imperalis*, are the lower altitude medicinal plants, which exhibit wider ecological adaptability, facilitating their wider cultivation specifically in their native range, China (Paek *et al.* 2002).

Due to the high medicinal properties, along with increasing trade demand for the supply of FC*,* microbiological interventions. Therefore, plant-microbe interaction plays a vital role in the conservation and long-term sustainability of the threatened medicinal plants of alpine regions, attenuates the pressure on wild species of FC*,* and fulfills the requirement of sustainable sources for the local population, who rely on FC for their livelihood. The IUCN Red List suggests that domesticating and cultivating the threatened medicinal plants near their natural habitat for the people who use them (Dhyani *et al.* 2022) alleviates the unsustainable harvesting of the wild population. It is necessary to identify several habitats, climatic zones, and growing media that are beneficial for the domestication of endangered medicinal plants (Dhyani *et al.* 2022). By integrating the analysis of the plant, the study highlighted the contribution to medicinal uses, posing a comprehensive understanding of their therapeutic potential and the recent research trend.

Limitation

The study has several limitations when using bibliometric analysis of *Fritillaria cirrhosa* D. Don. One potential challenge is that the number of published literature is relatively small. This further limits the quantitative indicators and may weaken network-based analyses, such as co-citation mapping and co-authorship. Secondly, most of the published documents are from China. Therefore, language bias further affects data breadth, as relevant studies published in non-English languages, particularly Chinese and Indian regional languages, may be underrepresented. Additionally, relying on broad indexing databases such as Web of Science or Scopus introduces bias, as a considerable proportion of ethnobotanical, species-specific, and conservation-related studies may be published in books, regional journals, reports, and other forms of literature that are not indexed. Therefore, the bibliometric findings should be interpreted as indicative rather than exhaustive, reflecting patterns within indexed literature rather than the full extent of research conducted on *Fritillaria cirrhosa*. Despite certain limitations of the studies, such as reliance on a single database (Scopus), the visualization parameters used in the bibliometric analysis could slightly affect clustering outcomes. The study offers an insightful overview of current research and provides future scientific evidence for the conservation planning of the species. This is the first-ever bibliometric analysis, which potentially provides statistical evidence to the scientific community for further advancement in the area.

Future Direction and Conclusion

Fritillaria cirrhosa is one of the most valuable forest-based products, particularly from the alpine region, that can make a significant contribution to the local economy. *Fritillaria cirrhosa* is a Non-Timber Forest Product (NTFP) that could serve as a livelihood source for the surrounding alpine communities. The increasing trade and the immense phytochemical and medicinal uses make the species more valuable, and immediate conservation strategies are required to protect the wild population. This Bibliometric analysis highlights that FC is a potentially impactful research study. Therefore, China has become one of the most cited countries, followed by Hong Kong and India. Authors like GUO Y and CUNNINGHAM AB have high citation rates. Further, Sichuan University and Chengdu University are the top two universities that published the most documents from 1939 to 2025. The study further indicates that some frequently used keywords, such as *Fritillaria cirrhosa*, peiminine, peimine alkaloid, medicinal plant, traditional medicine, etc., are more prominent in the studies. The keyword analysis also interprets that the most commonly searched bioactive compounds are peimine and peiminine (Fig. 6). Further, thematic mapping potentially indicates the ecological threat to the FC as well (Fig. 7). Overall, the bibliometric study suggests that the research output of the Fritillaria in terms of publication and citation rates is very less in countries like India and other Asian countries as compared to China, despite the studies related to FC with respect to documents and citation records having become one of the hot research interests since 2023, compared to earlier years. However, in India, there is a lack of publications, and citation rates and affiliations related to the species are low. However, the species is widely reported in Asian countries, including Nepal, Pakistan, and India. The trends in academic research, as analyzed through bibliometry, revealed that scholarly activities, such as article production, citation rates, affiliations, and collaborations, are more commonly observed in China compared to other reported Asian countries due to the diverse native range of *Fritillaria cirrhosa* and significant national collaboration within the universities with high document records from the authors. Consequently, in-depth studies, academic research, and international collaborations are still required in other countries to fully understand the benefits of this potential medicinal herb in their ecological habitats. This study might also be quite helpful for promoting community-based conservation of the species in the native regions of India, Nepal, Pakistan, etc., through capacity building, local stakeholder participation, and knowledge dissemination to surrounding communities, highlighting the importance of this invaluable medicinal plant. The study highlights the gaps in research publications on *Fritillaria cirrhosa* in native Asian countries outside China. This recommends publishing more research by the native countries and strengthening interdisciplinary collaborations among researchers. It might be promoting the conservation biology, pharmacology, and data-based management of the plant in other countries.

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